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California Institute of Technology
Pasadena, California

Assessment of Planetary Protection and Contamination Control Technologies for Future Planetary Science Missions

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Topics

- Purpose of Assessment
- Methodology
- Contents of Report
- Findings and Recommendations
  - System Engineering
  - Technology Development
  - Education and Training

Purpose of Assessment

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- NASA PSD requests JPL undertake periodic technology assessments
- Many such reports have been made *e.g.*
  - 2004 Energy Storage Technologies for Future Space Science Missions
  - 2005 Planetary Protection and Contamination Control Technologies for Future Space Missions
  - 2007 Extreme Environments for Future Space Science Missions
  - 2012 Guidance, Navigation and Control for Future Planetary Science Missions
    - *Part I Onboard and Ground Navigation and Mission Design*
    - *Part 2 Onboard Guidance, Navigation and Control*
    - *Part 3 Surface Guidance, Navigation and Control*
- This 2011 study revisits the original 2005 technology assessment with the intention of updating the technology needs in light of new science results, technology development, and programmatic priorities.
  - set of planned missions has been significantly revised since 2005
  - this assessment focuses on technologies and practices relevant to the projected mission set at that time.

Assessment Report

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Describes advances in both areas since 2005, when the primary emphasis was on technologies for *in situ* missions to Mars.

- As a result of the 2011 Planetary Science Decadal Survey Report, *Vision and Voyages for Planetary Science in the Decade 2013–2022*, the focus is now on a sequence of Mars sample return missions and possibly an Europa mission.
- We examined experiences in returning solar wind and cometary samples, which teach us how to better prepare for returning samples from Mars.
- At the time of the report's publication, there were three options for the Europa mission ranging from multiple fly-bys, to an orbiter or a lander.

Provides the status of planetary protection and contamination control technologies *as they apply to potential missions* and provides findings and recommendations to improve our capabilities as we explore our solar system.

Linking planetary protection and contamination control requirements and processes together early in the mission development and spacecraft design is key to keeping mission costs in check and returning high-quality samples that are free from biological and organic contaminants.

Along with Protecting Planets, Scientific integrity is a priority!

Methodology

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- Over a six-month period in 2010, the lead author interviewed a number of scientists, systems engineers, planetary protection engineers, program officers, and consultants from NASA and ESA.
- The study team collected information describing the state of the art in planetary protection practice and organic analysis.
- The team then combined this information with the current understanding of missions in the planning stages, and revisited them after the 2011 Planetary Science Decadal Survey was published.
  - This allowed the team to identify the needs with highest priority in meeting the envisioned mission objectives.
- The Steering Committee jointly created findings and recommendations.
  - System Engineering
  - Technology Development
  - Education and Training
- Report focuses on the needs for robotic exploration although human exploration poses new challenges to planetary protection of Mars
  - Some of the approaches and recommendations may be applicable to both.

Table of Contents

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Example of Status of Technologies and Progress since 2005 Report

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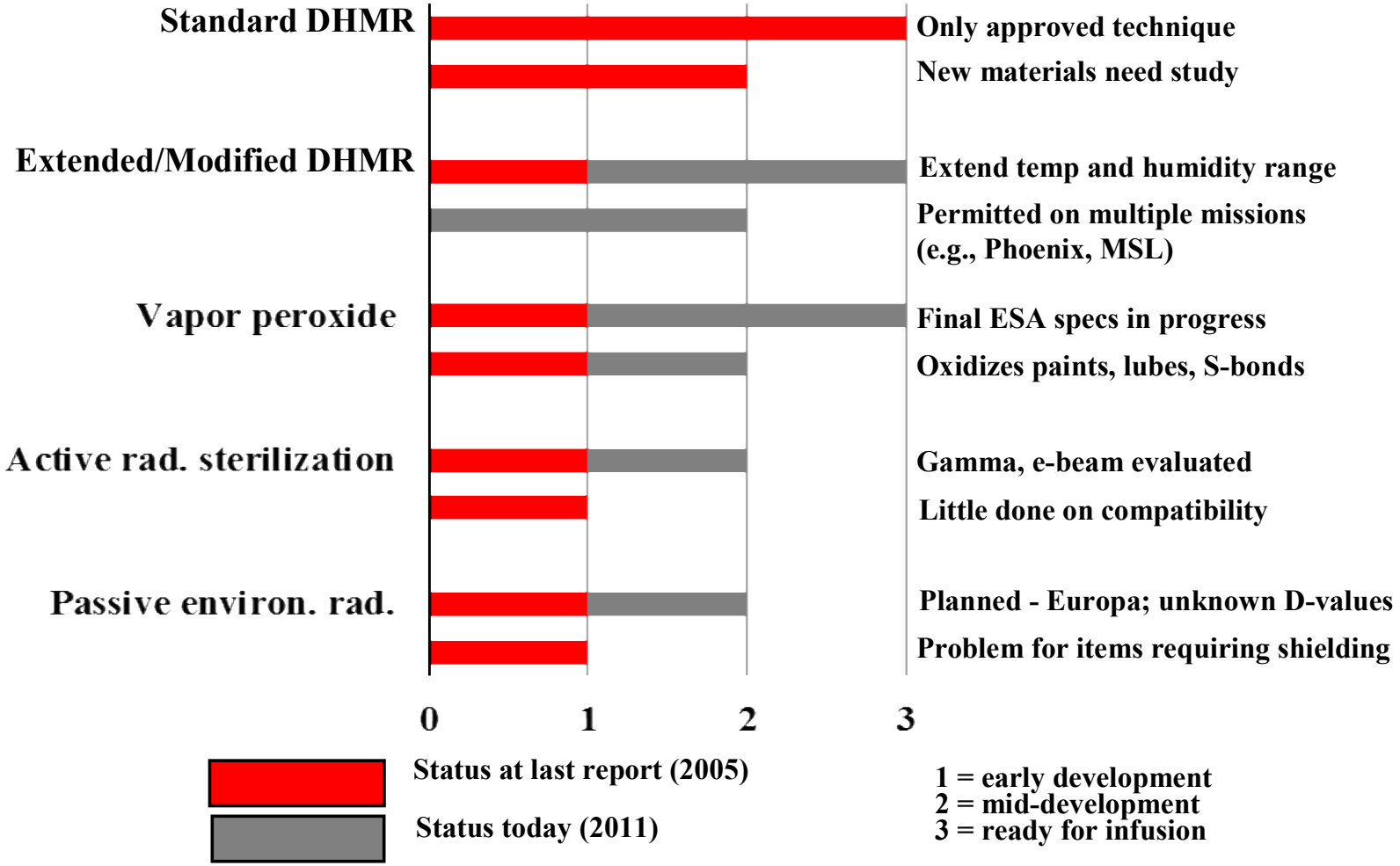

Figure 3-2. Summary of the status of microbial reduction technologies, describing sterilization modalities. There are two topics for each modality represented: 1) its progress toward NASA approval as a sterilization technique (first line) and 2) compilation of a hardware compatibility chart (second line).

Summary of Bio-burden Detection and Assessment Technologies

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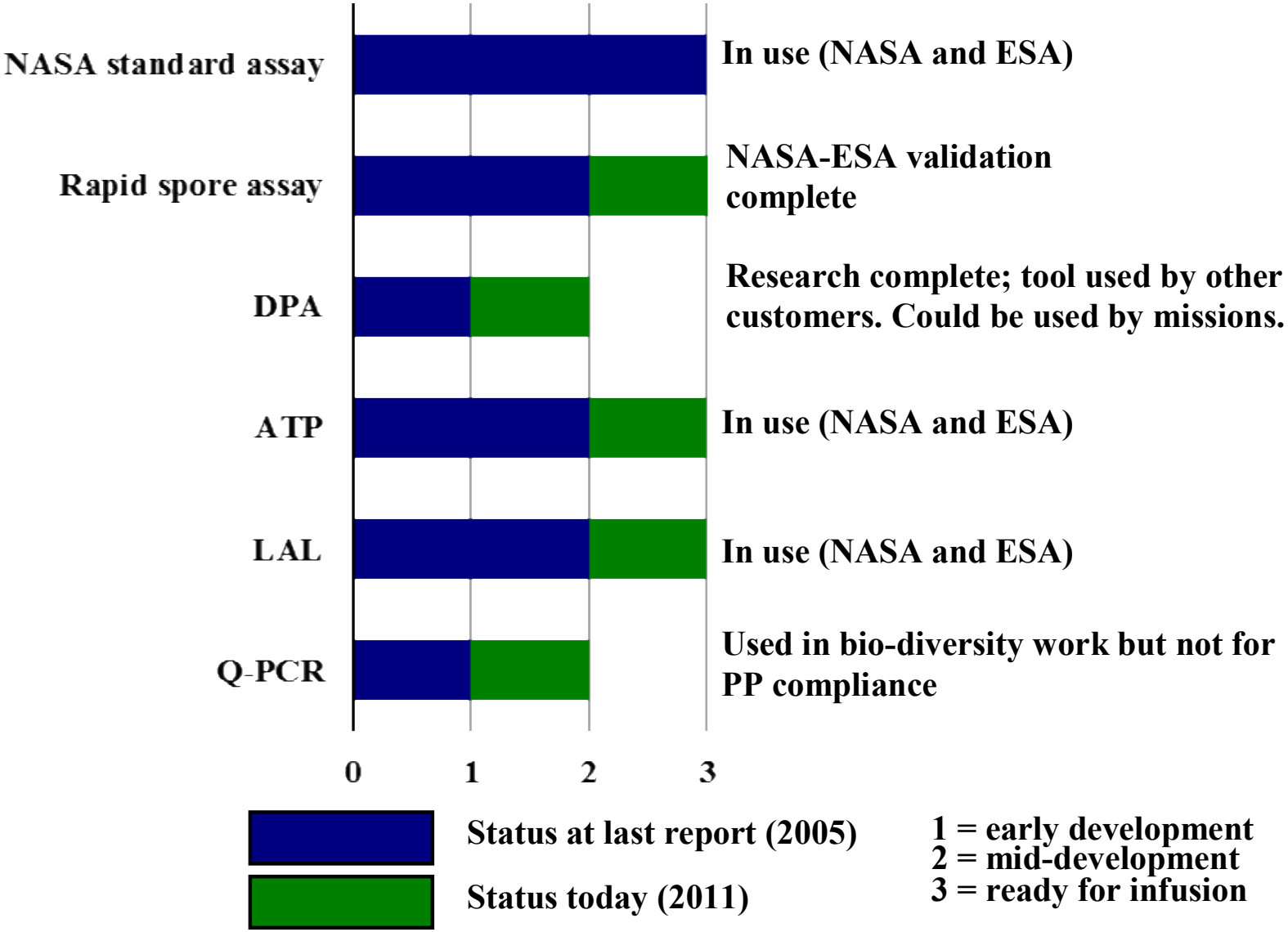

Summary of Research in Bio-diversity Studies

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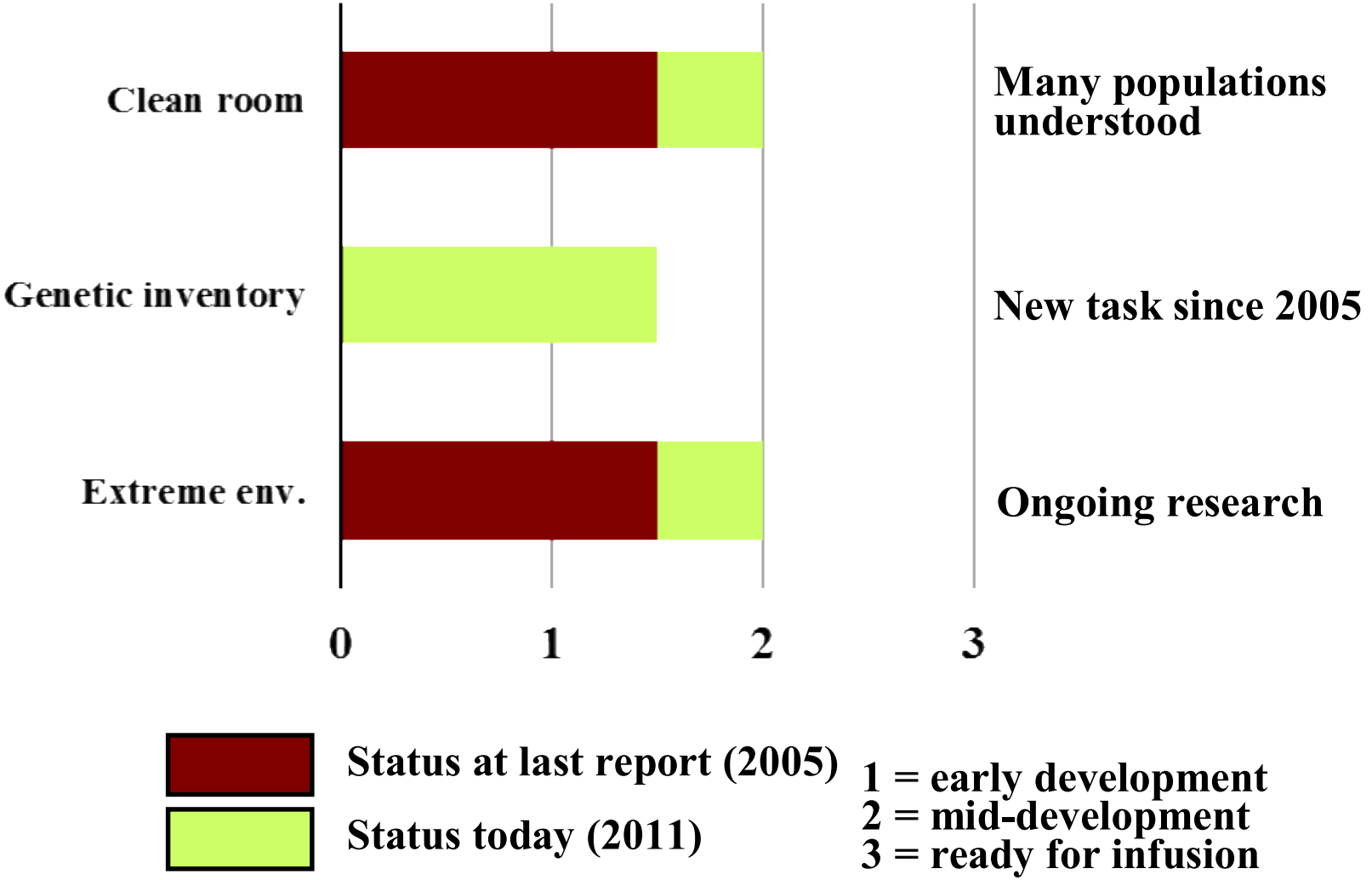

Summary of Technologies for Contaminant Transport

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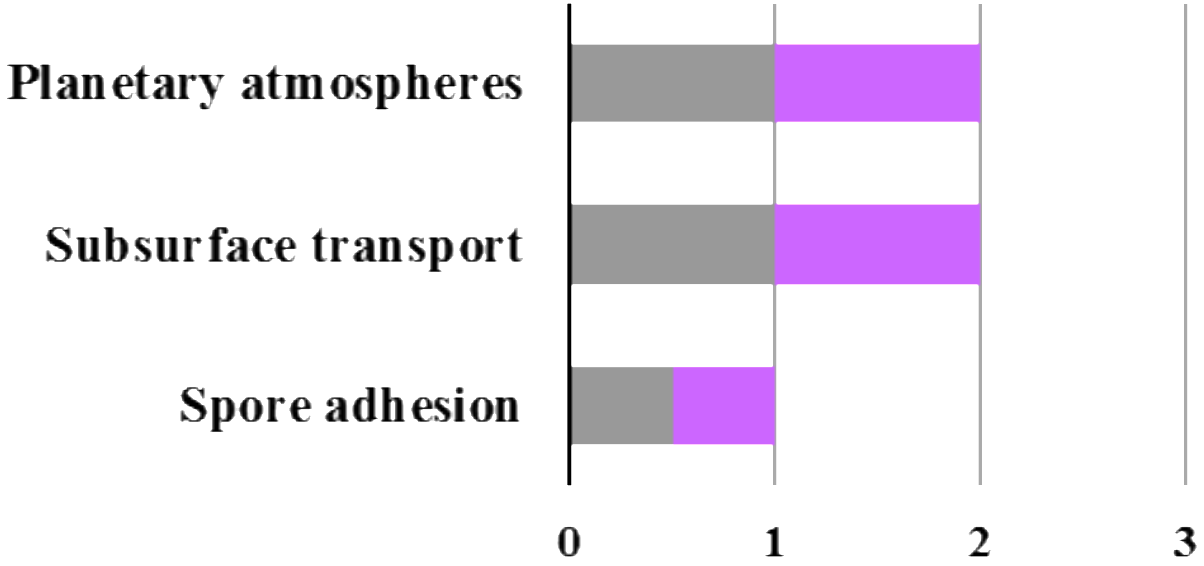

New models exist for Mars

New models exist for Mars and Europa

Some work funded by MTP/PPO; more work needed

Status at last report (2005)

Status today (2011)

1 = early development
2 = mid-development
3 = ready for infusion

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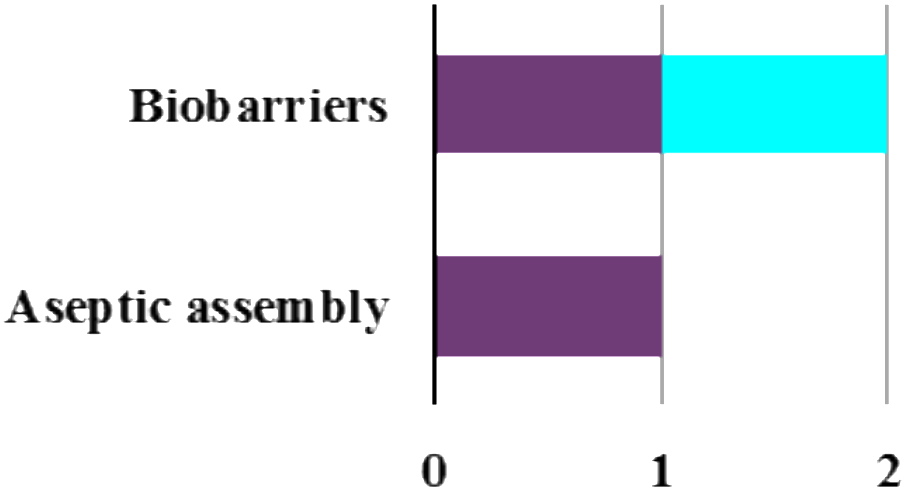
Summary of Isolation Technologies



Mostly implemented at project level

Some facilities have been identified

Status at last report (2005)

Status today (2011)

1 = early development
2 = mid-development
3 = ready for infusion

Findings and Recommendations

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Systems Engineering

Finding: Systems engineering education, tools, and capabilities typically do not extend to contamination control and planetary protection.

- *Recommendation:* The elements of contamination control and planetary protection that are critical to mission planning, science, and hardware design must be a fundamental part of the systems engineering and must be addressed at the earliest stages of the mission to ensure proper flow-down of requirements and cost-effective mission planning.

Findings and Recommendations

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Technology Development

Finding A: In the last five years, there has been impressive progress ın certain areas of forward-planetary protection technology

- *Recommendation A:* A streamlined approval process should be developed, as well as instruction on the newly available forward-planetary protection techniques. Plans for MSR technology development for assured containment must be carefully coordinated with concept studies and formulation efforts.

Finding B: Levels of interest for particle redistribution models have been based on optical performance of contamination-sensitive systems. These models generally ignored the redistribution of particles smaller than 50 μm as they were not a large contribution to the loss of performance (mainly caused by particles larger than 100 μm).

- *Recommendation B:* The effect of non-uniform molecular contamination on micron and submicron particle contamination levels should be determined.

Findings and Recommendations

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Education and Training

Finding A: NASA Solicitations for low-TRL instrument technology development proposals do not address planetary protection; therefore, technologists looking toward potential MSR or Europa missions may not be aware of the planetary protection requirements or implementation techniques, and thus are not designing their technologies to meet these requirements even though the technology is still at an early stage and consideration of these requirements at an early stage could significantly reduce overall instrument costs.

- *Recommendation A:* NASA Solicitations for early instrument technology development should include requirements for planetary protection. Education and training should be offered to all interested proposers at a level commensurate with the proposed efforts.

Findings and Recommendations

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Education and Training

Finding B: Contamination control experiences are not being captured in adequate form. This experience base stretches back to the Apollo era, is held by dozens of widely dispersed persons (many now retired), and is not recorded in any convenient place. In fact, most of the information is effectively not recorded at all.

- *Recommendation B:* NASA should support the creation of a living document detailing experiences with contamination control and curation for previous missions, to help present and future missions avoid costly mistakes.

Summary

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- Multi-institutional team provided data and evaluated the state of practice in Planetary Protection and Contamination Control
- Report discusses the status of technologies.
- Study team also evaluated other challenges
  - System Engineering
  - Education and Training
- Findings and Recommendations generated that would improve existing practices.
- Report posted on the Solar System Exploration website:

  http://solarsystem.nasa.gov/scitech/display.cfm?ST_ID=828
- Report also available in hardcopy
  - Patricia.Beauchamp@jpl.nasa.gov